



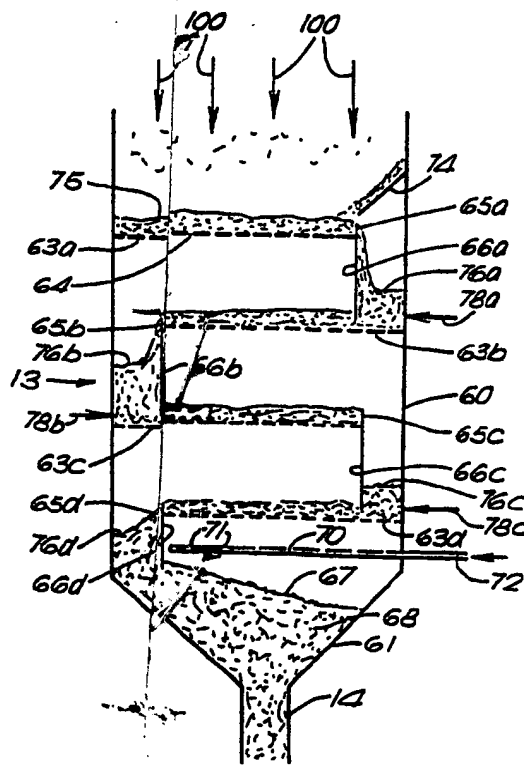
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(54) Title: CATALYST STRIPPER UNIT AND PROCESS IN CATALYTIC CRACKING OPERATIONS

(57) Abstract

A novel catalyst stripper unit and a catalyst stripping process for catalytic hydrocarbon cracking operations are described. The stripper comprises a stripper vessel (60) containing stacked, vertically separated, perforated trays (63), each having an overflow weir (65) defining the maximum depth of a layer of catalyst particles thereon. Each weir (65) forms the top end of a respective downcomer tube (66) which delivers catalyst particles from one tray to the tray immediately beneath at a location which is diametrically opposite the weir (65) of that tray so that particles must pass across the tray before overflowing the weir and descending to the next lower tray. Steam (or another stripping medium) is passed (72) into the bottom of the stripper vessel (60) and rises via the perforations in the trays and via the layers of fluidized particles of catalyst maintained thereon by the weirs (65), thereby stripping hydrocarbon materials from the catalyst particles. The steam containing stripped hydrocarbon materials may be received above the stripper vessel in a separator (12) forming part of the catalytic cracker reactor, and stripped catalyst particles are recovered from the base of the stripper vessel.



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CATALYST STRIPPER UNIT & PROCESS IN CATALYTIC CRACKING OPERATIONS

The present invention relates to a catalyst stripper unit and process employed in catalytic cracking operations.

In catalytic cracking operations, a hydrocarbon feedstock is contacted with particles of cracking catalyst at hydrocarbon cracking conditions. The feedstock is converted to vapor-phase products which are recovered, and also to non-vapor phase products. The latter include carbonaceous materials which form a coke-like deposit on the catalyst particles, and also hydrocarbon materials which are adsorbed on and occluded in the catalyst particles. Hydrocarbon materials also tend to be retained between catalyst particles in the so-called "emulsion phase". Since the said hydrocarbon materials are potentially valuable, it is conventional practice to attempt to recover them by contacting the catalyst particles with which they are associated with a stripping gas, usually high-temperature steam. Often, the contact with stripping gas is effected in a stripping zone, separated from the zone in which the cracking is effected, although it will be appreciated that the cracking and stripping can be effected in the same zone at different times. The contacting with stripping gas is usually performed in a counter-current manner, with catalyst passing downwardly and stripping gas passing upwardly, whereby stripped catalyst is recovered at the bottom region of the stripping zone and stripping gas containing stripped hydrocarbon materials is recovered at the top region of the stripping zone. In a common arrangement, the stripping zone contains an array of layers of rods extending across the stripping zone to prevent the descending catalyst particles from passing downwards in an uninterrupted vertical path, whereby better contacting (from the stripping point of view) between the particles and the stripping gas is obtained. Each rod may have a cross-section which is in the form of an inverted letter 'v' : such rods are known as "sheds". The increased separations between particles caused by the rods enhances the ability of the stripping gas to entrain emulsion-phase hydrocarbon materials.

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Although known expedients for stripping hydrocarbons from catalyst with stripping gas are reasonably effective, stripped catalyst particles contain further quantities of potentially strippable hydrocarbon material. Since the next operation to which the catalyst particles is usually subjected is oxidative regeneration to remove the coke-like deposit therefrom, the strippable hydrocarbons associated with the catalyst particles will be converted to coke and oxidized coke products during the regeneration operation and thereby lost. The amount of strippable material associated with the stripped catalyst particles not only detracts from the value of the cracked products, but also increases the amount of oxygen required for the regeneration step and increases the heat and gas output therefrom. In some catalytic cracking operations, the capacity of the air blower supplying air to the regenerator may be a factor limiting the throughput of feed and/or the conversion of the catalytic cracking unit. It will therefore be appreciated that any improvement in improving the efficiency of the stripping operation is likely to improve the economics of the catalytic cracking operation.

European published patent application EP-A-254333 describes and claims an integral hydrocarbon catalytic cracking conversion apparatus for the catalytic conversion of a hydrocarbon feed material to a hydrocarbon product material having smaller molecules which comprises :

(a) an elongated catalytic downflow reactor having a top and bottom portion comprising a hydrocarbon feed inlet at a position juxtaposed to said top portion of said downflow reactor, a regenerated catalyst inlet at a position juxtaposed to said top portion of said downflow reactor and a product and spent catalyst withdrawal outlet at a position juxtaposed to said bottom portion of said downflow reactor;

(b) an elongated upflow catalytic riser regenerator having a top and bottom portion for regeneration of said spent catalyst passed from said catalytic downflow reactor having a spent catalyst inlet at a position juxtaposed to said bottom portion of said regenerator, a regeneration gas inlet means for entry of an oxygen-containing gas at a position juxtaposed to said bottom portion of said regenerator and a regenerated catalyst and

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vapor phase outlet at a position juxtaposed to said top portion of said regenerator, said outlet having a means suitable to remove regenerated catalyst and vapors resultant from the oxidation of coke, present on said spent catalyst, with said oxygen-containing regeneration gas;

(c) a horizontal cyclonic separation means for separating spent catalyst from hydrocarbon product material, said horizontal cyclone separation means being in communication with said bottom portion of said catalytic downflow reactor and said bottom portion of said upflow riser regenerator;

(d) a connection separation means communicating with said top of said upflow riser regenerator and said top of said catalytic downflow reactor to separate regenerated catalyst, derived from said upflow riser regenerator, from spent oxidation gases, said means providing relatively dense phase of catalyst intermediate said top of said upflow regenerator and said top of said catalytic downflow reactor; and

(e) a pressure reduction means for obtention of a higher pressure in said second relatively dense phase immediately upstream of catalytic downflow reactor than the pressure in said top portion of said catalytic downflow reactor.

In drawing Figure 3 of EP-A-254333, there is depicted a catalyst stripping unit comprising two vertically-spaced dense phases of catalyst, and a dip leg connecting the upper dense phase with the lower dense phase. The upper dense phase receives unstripped catalyst from the downflow reactor in which hot regenerated catalyst is contacted with the feed. Steam is injected into the lower dense phase from two sources thereof, and stripped, spent catalyst is withdrawn from the bottom of the stripper unit and passed to a dense phase bed of the riser regenerator. EP-A-254333 provides no disclosure of the construction or operation of the stripper unit nor of the modes of flow of the solids and gas/vapour phase materials therein.

UK published patent application GB-A-2166662 describes and claims an apparatus for separating hydrocarbon products from catalyst particles comprising a cyclone separator, an inlet for introducing into the cyclone

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separator a mixture of catalyst particles and hydrocarbon products, an outlet for removing gases from the cyclone separator which outlet is so arranged near the upper end of the cyclone separator that an annular space is formed between the walls of the outlet and the cyclone separator, and a stripper assembly having an outlet for gases and comprising at least two interconnected stripper vessels of which the first stripper vessel is in fluid communication with the lower end of the cyclone separator and of which the last stripper vessel is provided with an outlet for catalyst particles, wherein the cyclone separator is provided with means for introducing primary stripping gas into the cyclone separator, and wherein the stripper assembly is provided by means for introducing secondary stripping gas into the stripper vessels. The said interconnected stripper vessels are formed by dividing a vessel having a permeable base into a series of chambers by means of baffles which project upwardly from the base. The baffles are separated in a horizontal sense, and the baffle nearest one end of the vessel is higher than the baffle which is next-nearest to the said one end. The latter baffle is, in turn, higher than the baffle which is yet next-nearest to the said one end. Catalyst from a hydrocarbon cracking stage is received in the chambers defined by the baffles, and is stripped therein by a stripping gas supplied via the permeable base. Each chamber is separately supplied with stripping gas, and the distribution of stripping gas to each chamber is non-uniform. Stripped hydrocarbon material is recovered from the common space above each chamber. Each chamber receives fresh stripping gas at the base thereof, and the efficiency of utilization of stripping gas is therefore relatively low.

UK patent specification GB-A-744687 describes and claims a process for hydroforming hydrocarbon fractions, wherein the hydrocarbon fractions are contacted in a reaction zone, under hydroforming conditions, with a dense fluidized bed of hydroforming catalyst particles and in the presence of a hydrogen-containing gas, and continually withdrawing from the reaction zone spent catalyst particles and transferring them to a regeneration zone wherein they are maintained in a fluidized state under regenerative conditions whereby carbonaceous deposits are burnt from the said spent catalyst particles, and regenerated catalyst particles are thereafter

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returned to the reaction zone, characterized in that the spent catalyst particles are maintained under regenerative conditions in the said regeneration zone for at least 35 minutes.

The regeneration zone is in the form of a regenerator vessel which comprises a vertical, elongated vessel, inlet means for the introduction of spent catalyst particles and regeneration gas into the upper part of said vessel, an outlet line for the withdrawal of regeneration gas substantially free of catalyst particles in the top of said vessel, an outlet line for the withdrawal of regenerated catalyst particles in the bottom of said vessel, inlet means for the introduction of additional regeneration gas at the lower part of said vessel, and baffle means within said vessel below the inlet means for spent catalyst particles and regeneration gas in the upper part of said vessel and above the inlet means for the introduction of additional regeneration gas in the lower part of said vessel.

The regeneration step is performed at high temperatures in the presence of oxygen to remove carbonaceous deposits from the hydroforming catalyst particles by oxidation.

The present invention provides a catalytic cracking process wherein a hydrocarbon feed is contacted with cracking catalyst particles at cracking conditions, catalyst particles and vapors are separated, separated catalyst particles are stripped of emulsion phase and adsorbed and/or occluded materials by contact with a stripping medium under stripping conditions, stripped catalyst particles are contacted with an oxidizing gas whereby carbonaceous deposits thereon are oxidatively removed and the catalyst particles are heated, and thus-heated catalyst particles are contacted with further amounts of hydrocarbon feed, wherein the stripping of the catalyst particles is effected by passing the particles across at least one substantially horizontal tray in a layer of fluidized particles while causing the stripping medium to pass through the tray from underneath so as to pass in contact with particles in the layer.

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Preferably, fluidized particles from a layer on one tray pass to a layer on a subsequent tray spaced vertically therebeneath for a further stage of stripping by stripping medium. Preferably, stripping medium from the further stage of stripping on the said subsequent tray is employed to strip strippable material from the layer of particles on the said one tray.

Preferably, stripping medium containing stripped materials is recovered from above the highest tray and stripped catalyst particles are recovered from the layer of particles on the lowest tray.

Each tray may comprise an overflow weir defining the depth of the layer of fluidized particles thereon and a downcomer for receiving particles overflowing the weir and for directing said particles into the layer of a tray vertically spaced therebeneath.

Preferably, the particles have a predetermined mean residence time or a respective predetermined mean residence time in the layer on the or each tray.

Preferably, the or each tray is formed with, or defines, perforations for the upward passage of stripping medium therethrough and into the layer of particles thereon. Each tray may be formed from perforated metal sheet with or without a bubble cap surmounting each perforation, or perforations each having upright tubular openings with or without valve members therein, or it may comprise wire mesh or arrays of metal wires or bars or superimposed arrays of metal wires or bars.

The present invention also provides a catalytic cracking unit for converting hydrocarbons comprising a reactor zone in which regenerated or fresh catalyst particles are contacted with hydrocarbon feed at catalytic cracking conditions, a separation zone wherein catalyst particles from the reactor zone are separated from vapor-phase products, a stripping zone wherein catalyst particles from the separation zone are stripped of emulsion phase and adsorbed and/or occluded strippable material by contact with a stripping medium under stripping conditions, a regenerator zone wherein catalyst particles from the stripping zone are contacted with an oxidizing

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gas to remove carbonaceous deposits and thereby to regenerate and heat the catalyst particles, and wherein heated, regenerated catalyst particles are contacted with further amounts of hydrocarbon feed in the reactor zone, wherein the stripping zone comprises at least one substantially horizontal tray having an overflow weir defining the depth of a layer of catalyst particles on the tray, a downcomer for receiving catalyst particles which spill over the overflow weir, and means permitting stripping medium below the tray to pass therethrough and in contact with catalyst particles in the said layer to strip and fluidize particles in the said layer.

The unit may comprise a plurality of similar or like substantially horizontal trays stacked one above the other with a space between vertically-adjacent trays, the downcomer of one tray being arranged to direct catalyst particles received therein into the layer of catalyst on the tray immediately therebelow, and the arrangement permitting stripping medium from the latter tray to pass upwardly through the said one tray into the layer of catalyst particles thereon.

Preferably, the weir of each tray and the bottom end of the downcomer from which the tray receives catalyst particles are so arranged that catalyst particles will spend a predetermined average residence time on the or each tray. The weir of the or each tray may be at one side of the tray and the bottom end of a downcomer from which catalyst particles are received from the tray above may be at an opposite side thereof. Preferably, the bottom end of the downcomer at one tray is below the level of the top of the overflow weir of that tray. The downcomer from one tray may be substantially vertically above the weir and downcomer of the next-but-one tray therebelow.

The or each tray may be formed from perforated metal sheet with or without a bubble cap surmounting each perforation, or with perforations each having upright tubular openings with or without valve members therein, or the or each tray may comprise wire mesh or arrays of metal wires or bars or superimposed wire meshes or arrays of metal wires or bars.

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The unit preferably comprises means for passing stripping medium below the lowest tray of the stripping zone and means for receiving stripping medium and stripped strippable materials above the highest tray of the stripping zone. Preferably, the tray or trays and each respective weir and downcomer are received within a stripping vessel which receives unstripped catalyst particles at the top region thereof from the separator zone and stripping medium at the bottom region thereof.

The invention further provides a catalytic cracking process performed in the novel unit as described herein.

The invention also includes cracked products whenever made by the novel process described herein.

During correct operation of the catalytic cracking unit of the present invention, the stripping medium is distributed substantially uniformly and thoroughly into the dense phase catalyst particles bed held up on the or each tray via the perforations or holes defined by the respective tray. The or each catalyst bed is maintained in a stable fluidized state, without significant quantities of catalyst "weeping" through the perforations or holes in the tray(s) and with acceptable catalyst entrainment into the dilute phase above the/each tray. Good contacting occurs between the issuing bubbles of stripping medium and the dense catalyst particles emulsion for relatively rapid and efficient flushing away of hydrocarbon vapors surrounding each catalyst particle. This is a highly desirable result from the following viewpoints : (1) it minimizes or reduces the production of coke in the stripper which would otherwise result from continued reactions therein, and (2) it maximises or enhances the concentration gradient for subsequent effective hydrocarbon desorption from the catalyst pores into the emulsion phase (in the spaces or voids between solid catalyst particles) and further hydrocarbon removal. The average residence time of each catalyst particle in the stripper is preferably no greater than 60 seconds, which facilitates efficient and relatively complete stripping.

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The invention will now be further described by way of non-limitative example only, and with reference to the accompanying diagrammatic drawings, in which:-

Figure 1 is a diagram (not to scale) of the principal features of a known fluidized catalytic cracking unit ("FCCU");

Figure 2 is a diagrammatic cross-section of a stripper embodying the invention; the stripper being shown to a larger scale than the FCCU of Figure 1, and only sufficient detail being illustrated for an understanding of its construction and mode of operation; and

Figures 3a and 3b show, diagrammatically, plan views of two different arrangements of trays which can be employed in the stripper of Figure 2.

Reference is first made to the FCCU 10 of Figure 1 which comprises a reactor vessel 12 surmounting a stripper 13, the conical bottom of which communicates via a U-bend pipe 14 with a riser 15, the top of which is located within a regenerator vessel 16 at a level above the conical bottom thereof and slightly above a perforated grid 17 which extends across the top of the conical bottom. The regenerator 16 contains fluidized particles of cracking catalyst in a bed 18 which extends up to a top level 19 in the regenerator. Catalyst which tends to rise above level 19 overflows into the top region 20 of a downcomer 21 which is connected to one end of a U-bend pipe 22. The other end of the pipe 22 is connected to a riser 23 which extends substantially vertically and generally upwardly to a termination device 24 defining the top of the riser 23. Each U-bend pipe 14 and 22 has a respective closure valve 26, 27 for emergency and maintenance closing of the flow passages therethrough.

In broad terms, the operation of the FCCU 10 proceeds as follows: a hydrocarbon feed, usually consisting of, or containing, fractions boiling in the gas oil range and higher, is passed into a lower part of the riser 23 from a feed line 30. Usually, the feed from line 30 is introduced into the

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riser 23 via a plurality of injectors (not shown) arranged equiangularly around riser 23. Hot regenerated catalyst particles passing upwardly through the riser 23 mix with, and heat, the injected feed in the riser 23 at the level of the feeds injectors and higher causing selective catalytic conversion of the feed to cracked products, which include vapor-phase cracked products, and carbonaceous and tarry cracked products which deposit on, and within the pores of, the catalyst particles. The mixture of catalyst particles and vapor-phase products enters the reactor vessel 12 from the riser 23 via apertures (not shown) in the side of the riser termination device 24, whereby to promote the separation of solids from vapors in the reactor vessel 12. Vapors together with entrained solids pass into a cyclone separation system which is herein shown to comprise two cyclones 31 and 32. The cyclone 31 provides primary separation of vapors and entrained solids, a major part of the latter being returned to the base of vessel 12 via a dipleg 33. The solids-depleted vapors from primary cyclone 31 are conducted via pipe 34 to the secondary cyclone 32 for further solids-separation, the separated solids being returned to the base of vessel 12 via dipleg 35, and cracked vapor products are recovered from cyclone 32 via conduit 36, plenum 37 and product line 38.

The catalyst particles from riser 23, together with separated solids from the cyclones 31 and 32, pass downwardly into the top of the stripper 13 wherein they are contacted by upwardly-rising steam injected from line 40 near the base thereof. The steam strips from the particles adsorbed and occluded strippable hydrocarbons, and flushes away emulsion phase hydrocarbons, and the stripped and flushed hydrocarbons, together with the stripping steam, are recovered with the cracked products in product line 38.

Stripped catalytic particles bearing carbonaceous deposits circulate from the conical base of stripper 13 via the U-bend pipe 14 and the riser 15 into the bed 18 of catalyst particles contained in the regenerator vessel. The circulation of particles via the pipe 14 is promoted by control air which is passed into a lower region of the riser 15 from line 42.

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The catalyst particles in the bed 18 are fluidized by air passed into the base of reactor vessel 16 from line 43. The air oxidatively removes carbonaceous deposits from the particles and the heat of reaction (e.g., due to combustion and part-combustion) raises the temperature of the particles in the bed to temperatures suitable for cracking the feed hydrocarbons. Hot regenerated catalyst overflows the top region 20 of the downcomer 21 and passes via the downcomer 21 into the U-bend pipe 22 for contact with further quantities of feed supplied from line 30.

The spent air passing upwardly from the top level 19 of the bed 18 in regenerator vessel 16 enters a primary cyclone 45 for separation of entrained particles, the latter being returned to the bed 18 via a dipleg 46. A further stage of solids separation is effected by secondary cyclone 47 which receives the solids-depleted gas from the primary cyclone 45, the separated solids being returned to the bed 18 via a dipleg 48. Spent air is recovered from the top of the regenerator vessel conduit 49.

Reference is now made to Figure 2 of the drawings which shows diagrammatically, and to a larger scale, the principal features of a novel stripper 13 which can be used with advantage in the FCCU shown in Figure 1.

The stripper 13 comprises a cylindrical vessel 60 having a conical bottom 61. Catalyst particles with which are associated emulsion phase hydrocarbon material and adsorbed, occluded and deposited hydrocarbon materials, in addition to coke-like carbonaceous deposits, are received at the top end from reactor vessel 12 (as indicated by the arrows 100), and stripped catalyst particles leave the conical base 61 of the stripper via the top of U-bend pipe 14.

Within the cylindrical vessel 60, there are provided a plurality of vertically separated trays 63a, 63b, 63c, 63d. In practical embodiments, there may be more or less trays, the four trays illustrated being for the purpose of exemplification and explanation only. The trays 63 may each have

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any form which permits the establishment of a layer of catalyst particles thereon while permitting a stripping medium to pass through the tray and through the layer of catalyst particles thereon thereby to fluidize the particles. In the illustrated embodiment, the trays 63 are of the type known as sieve trays, each tray being formed from a plate perforated by holes 64.

Reference is now made to Figures 3a and 3b which show, in diagrammatic form, the principal features of two typical trays 63 which can be used in the stripper 13 of Figure 2. The features which are shown are those which are necessary for an understanding of the construction of the trays by a person skilled in the art.

In the Figure 3a embodiment, the tray 63 is mounted so as to extend across the internal cross-section of the vessel 60. The tray 63 may be of perforated sheet metal or of the well-known sieve-tray construction employed in distillation columns, but suitably adapted for contacting catalyst particles thereon by stripping gas (e.g., steam) passing upwardly there-through, as would be understood by those skilled in the art. An arcuate slot 90 is formed over a suitable angular extent (e.g., about 90°) of the periphery of the tray 63, and the edge of the slot 90 is provided with an upstanding weir 65 to retain a predetermined level of catalyst particles on the tray 63. As catalyst particles are added to the tray in the region opposite the slot 90, catalyst particles overflow the top of the weir 65 and fall through the slot onto the tray 63 beneath, preferably onto a region thereof which is more or less diametrically opposite the slot 90 of the said tray 63. The weir 65 also extends below the plane of the tray 63 to form the downcomer 66 (shown in Figure 2) wherein catalyst particles accumulate to form a substantially vapour-tight seal preventing the passage of vapour-phase material up the downcomer 66.

Figure 3b shows a tray 63 which is similar to the tray of Figure 3a except that a chord 91 is omitted from part of the periphery of the tray, and the weir 65 (and the corresponding downcomer wall 66, not visible in Figure 3b) is straight.

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In the following description of Figure 2, trays 63 of the type shown in Figure 3a are employed.

At one end of each tray is an arcuate, cut-away hole, and an arcuate upstanding weir, respectively 65a, 65b, 65c, 65d, extends around the arcuate periphery of the respective hole and is welded (or otherwise attached) at its opposite ends to the interior of the cylindrical vessel 60. This manner of attachment is not shown but will be understood and appreciated by those skilled in the art.

Each weir 65 forms the upper end region of an arcuate sleeve of metal which extends below the respective tray 63 to define with the interior of the vessel 60 a respective downcomer 66a, 66b, 66c, 66d. The bottom end of each downcomer 66a, 66b, 66c is slightly lower than the top of the weirs 65b, 65c, 65d respectively. The bottom end of downcomer 66d is arranged to be at a level below the top level 67 of catalyst 68 which accumulates in the conical bottom 61 of the stripper, during operation of the cracking unit.

In the space between the top level 67 of catalyst 68 in the conical bottom 61 of the stripper vessel 13 and the lowest tray 63d is disposed a hollow ring distributor 70 having perforated walls (e.g. holes 71) to which is attached a feed line 72 for stripping medium. In the present description, the stripping medium is steam, but it will be known and understood by those skilled in the art that other stripping media can be employed.

Stripping steam passed into the ring distributor 70 from the feed line 72 passes upwardly through the stripper 13, via the holes in the trays 63d, 63c, 63b and 63a. The unstripped catalyst from the reactor vessel 12 descends initially onto the top tray 63a, an inclined deflector plate 74 extending over the top downcomer 66a preventing catalyst from the reactor vessel 12 passing directly into the top downcomer 66a. The catalyst accumulates on the top tray 63a to a level 75 which is determined by the weir 65a. The layer of catalyst thus formed on the top tray 63a is subjected to the stripping action of steam passing through the holes in tray

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63a, and the steam also maintains the catalyst particles on the tray in a fluidized state. The stripping steam together with stripped hydrocarbon material from the catalyst rises into the reactor vessel 12 and is recovered via product line 38.

As unstripped catalyst continues to descend from the reactor vessel 12 onto the top tray 63a, partly-stripped fluidized catalyst overflows the weir 65a and descends in the downcomer 66a where it accumulates to a level 76a and provides the catalyst which forms a layer on tray 63b, the depth of the layer being determined by the height of the weir 65b. Stripping steam passes through the holes in the tray 63b and strips catalyst thereon while maintaining the catalyst particles in a fluidized state, the resulting mixture of steam and hydrocarbon serving as the stripping medium for the layer of unstripped catalyst on the top tray 63a.

The excess of catalyst particles on tray 63b above the weir 65b overflows into the downcomer 66b where it accumulates to a level 76b, and is subsequently steam-stripped while in the catalyst layer on tray 63c. Catalyst enters the layer on tray 63c from the accumulation in the downcomer 66b at a rate which substantially equals the rate at which catalyst overflows the weir 65c and passes into the downcomer 66c, forming an accumulation therein up to a level 76c. The latter accumulation supplies catalyst to a catalyst layer on tray 63d up to a level dictated by the weir 65d, and catalyst in the layer on tray 63d is stripped by steam passing through the layer from the steam ring distributor 70 and the holes in tray 63d. The stripped catalyst overflowing the weir 65d in the downcomer 66d forms an accumulation therein up to a level 76d. The accumulations of catalyst in the downcomers substantially prevent stripping steam passing up the downcomers so that the catalyst is steam-stripped while on the trays 63. The height to which catalyst accumulates in each downcomer is a factor of the kinetics of operation of the stripper and those skilled in the art will know what dimensions to apply to the critical parts of the stripper to achieve desirable depths of catalyst accumulation in the downcomers and desirable residence times for the catalyst particles on each tray 65 and

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desirable steam-catalyst contacting rates on each tray 65. On each tray, the catalyst can approach equilibrium with respect to strippable hydrocarbon material removed therefrom and the stripper of the invention provides multiple countercurrent equilibrium stages which are superior and more efficient from the points of view of steam utilization, steam-catalyst contacting and stripping than known strippers.

In order to maintain the accumulations of catalyst in each downcomer 66 in a flowable condition, relatively small amounts of "aeration" steam are passed into the lower region of each accumulation in the downcomers 66 from respective aeration steam lines 78a, 78b, 78c.

The invention is not limited to the precise embodiments described and/or illustrated. For example, in Figure 2, each downcomer/weir may be at the centre of an annular tray rather than at the side as shown in the exemplary embodiments of Figures 3a and 3b. In such a construction, a deflector plate (preferably conical) will be disposed above each downcomer, somewhat after the fashion of an umbrella, to prevent overflowing catalyst from one tray passing down more than one downcomer at a time.

The process and apparatus of the present invention may be employed to achieve an effective hydrocarbon stripping operation in a catalytic cracking unit with, e.g., approximately 15 cm depth of fluidized catalyst on each tray, a tray spacing of about 1 m, a steam rate of about 4 kg/1000 kg catalyst and a superficial velocity of about 30 cm/s, employing several trays. Very efficient flushing of emulsion-phase hydrocarbon material, and enhanced desorption of adsorbed hydrocarbon material from catalyst particles can thus take place over the multiple quasi counter-current stripping stages provided by the trays. Catalyst residence time in the stripper may be of the order of 15 to 30 seconds compared with typical equivalent average dense bed residence times of 1 to 2 minutes. The reduction in residence time reduces the extent to which unstripped hydrocarbons can continue reacting to form coke deposits, thus making the unstripped hydrocarbons more available and susceptible for removal whilst in contact with steam in the stripper.

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CLAIMS:

1. A catalytic cracking process wherein a hydrocarbon feed is contacted with cracking catalyst particles at cracking conditions, catalyst particles and vapors are separated, separated catalyst particles are stripped of emulsion phase and adsorbed and/or occluded materials by contact with a stripping medium under stripping conditions, stripped catalyst particles are contacted with an oxidizing gas whereby carbonaceous deposits thereon are oxidatively removed and the catalyst particles are heated, and thus-heated catalyst particles are contacted with further amounts of hydrocarbon feed, wherein the stripping of the catalyst particles is effected by passing the particles across at least one substantially horizontal tray in a layer of fluidized particles while causing the stripping medium to pass through the tray from underneath so as to pass in contact with particles in the layer.
2. A process as in claim 1 wherein fluidized particles from a layer on one tray pass to a layer on a subsequent tray spaced vertically therebeneath for a further stage of stripping by stripping medium.
3. A process as in claim 2 wherein stripping medium from the further stage of stripping on the said subsequent tray is employed to strip strippable material from the layer of particles on the said one tray.
4. A process as in any one of claims 1 to 3 in which stripping medium containing stripped materials is recovered from above the highest tray and stripped catalyst particles are recovered from the layer of particles on the lowest tray.
5. A process as in any one of claims 1 to 4 wherein each tray comprises an overflow weir defining the depth of the layer of fluidized particles thereon and a downcomer for receiving particles overflowing the weir and for directing said particles into the layer of a tray vertically spaced therebeneath.

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6. A process as in any one of claims 1 to 5 wherein the particles have a (respective) predetermined mean residence time in the layer on the or each tray.

7. A process as in any one of claims 1 to 6 wherein the or each tray is formed with, or defines, perforations for the upward passage of stripping medium therethrough and into the layer of particles thereon.

8. A process as in claim 7 in which the or each tray is formed from perforated metal sheet with or without a bubble cap surmounting each perforation, or with perforations each having upright tubular openings with or without valve members therein, or the or each tray comprises wire mesh or arrays of metal wires or bars or superimposed arrays of metal wires or bars.

9. A catalytic cracking unit for converting hydrocarbons comprising a reactor zone in which regenerated or fresh catalyst particles are contacted with hydrocarbon feed at catalytic cracking conditions, a separation zone wherein catalyst particles from the reactor zone are separated from vapor-phase products, a stripping zone wherein catalyst particles from the separation zone are stripped of emulsion phase and adsorbed and/or occluded strippable material by contact with a stripping medium under stripping conditions, a regenerator zone wherein catalyst particles from the stripping zone are contacted with an oxidizing gas to remove carbonaceous deposits and thereby to regenerate and heat the catalyst particles, and wherein heated, regenerated catalyst particles are contacted with further amounts of hydrocarbon feed in the reactor zone, wherein the stripping zone comprises at least one substantially horizontal tray having an overflow weir defining the depth of a layer of catalyst particles on the tray, a downcomer for receiving catalyst particles which spill over the overflow weir, and means permitting stripping medium below the tray to pass therethrough and in contact with catalyst particles in the said layer to strip and fluidize particles in the said layer.

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10. A unit as in claim 9 comprising a plurality of similar or substantially like horizontal trays stacked one above the other with a space between vertically-adjacent trays, the downcomer of one tray being arranged to direct catalyst particles received therein into the layer of catalyst on the tray immediately therebelow, and the arrangement permitting stripping medium from the latter tray to pass upwardly through the said one tray onto the layer of catalyst particles thereon.

11. A unit as in claim 9 or claim 10 in which the weir of each tray and the bottom end of the downcomer from which the tray receives catalyst particles are so arranged that catalyst particles will spend a (respective) predetermined average residence time on the or each tray.

12. A unit as in claim 11 wherein the weir of the or each tray is at one side of the tray and the bottom end of a downcomer from which catalyst particles are received from the tray above is at an opposite side thereof.

13. A unit as in claim 12 in which the bottom end of the downcomer at one tray is below the level of the top of the overflow weir of that tray.

14. A unit as in any one of claims 9 to 13 wherein the downcomer from one tray is substantially vertically above the weir and downcomer of the next-but-one tray therebelow.

15. A unit as in any one of claims 9 to 14 wherein the or each tray is formed from perforated metal sheet with or without a bubble cap surmounting each perforation, or perforations each having upright tubular openings with or without valve members therein, or comprises wire mesh or arrays of metal wires or bars or superimposed wire meshes or arrays of metal wires or bars.

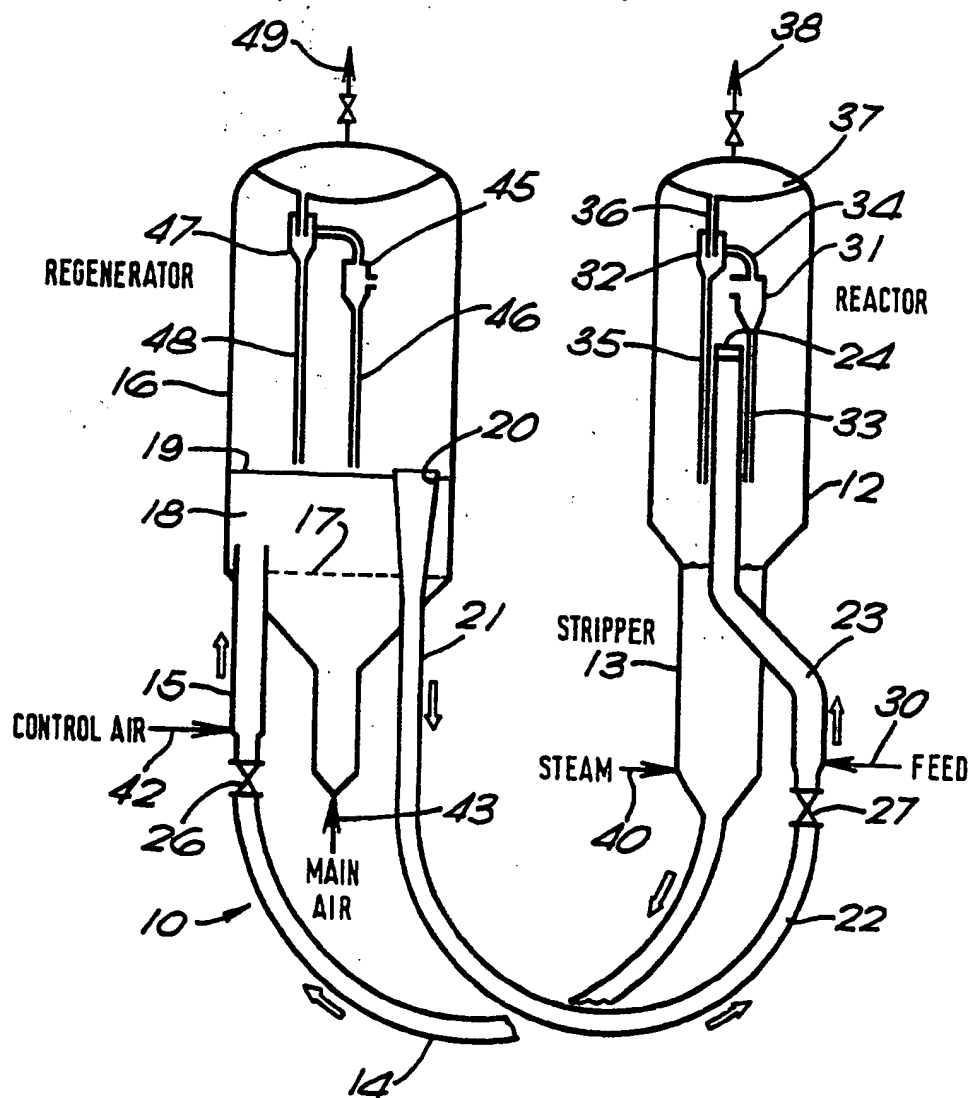
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16. A unit as in any one of claims 9 to 15 comprising means for passing stripping medium below the lowest tray of the stripping zone and means for receiving stripping medium and stripped strippable materials above the highest tray of the stripping zone.

17. A unit as in any one of claims 9 to 16 wherein the tray or trays and each respective weir and downcomer are received within a stripping vessel which receives unstripped catalyst particles at the top region thereof from the separator zone and stripping medium at the bottom region thereof.

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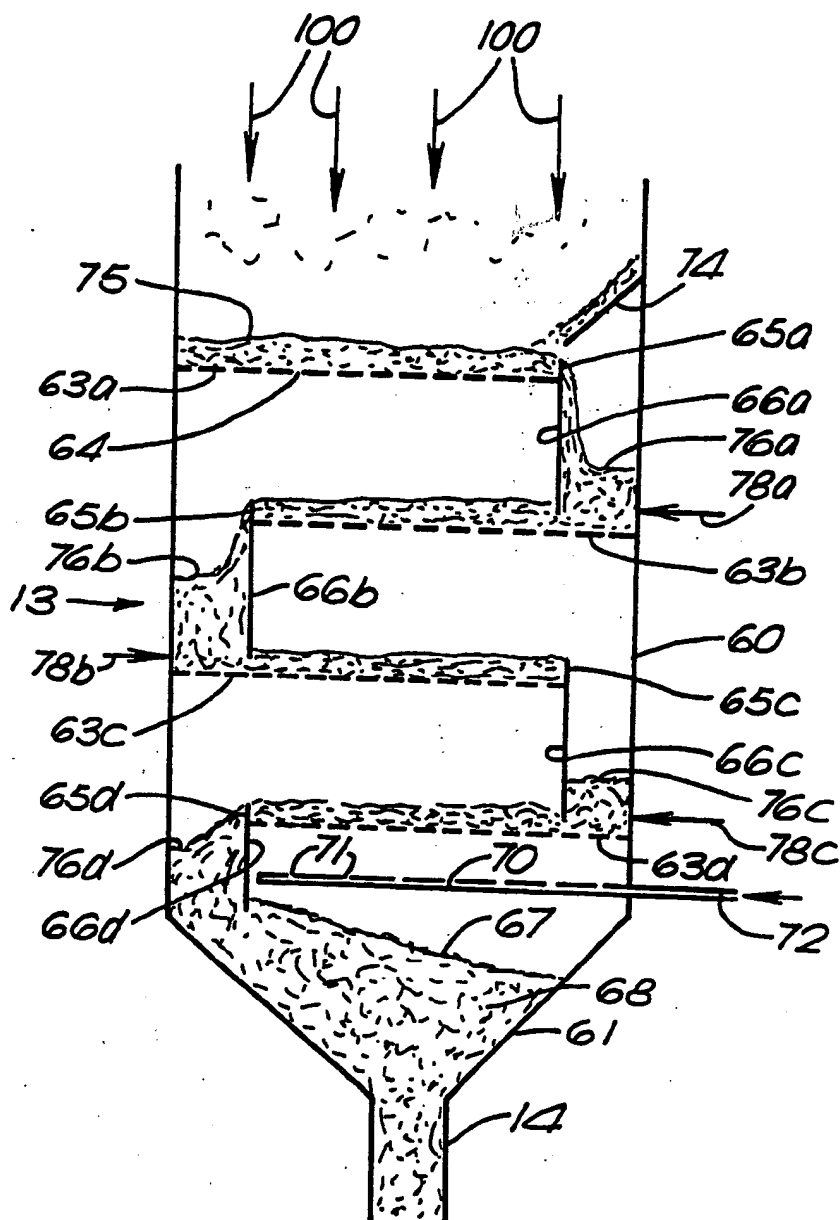
FIG. 1



SUBSTITUTE SHEET

$\frac{2}{3}$

FIG. 2



SUBSTITUTE SHEET

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FIG. 3a

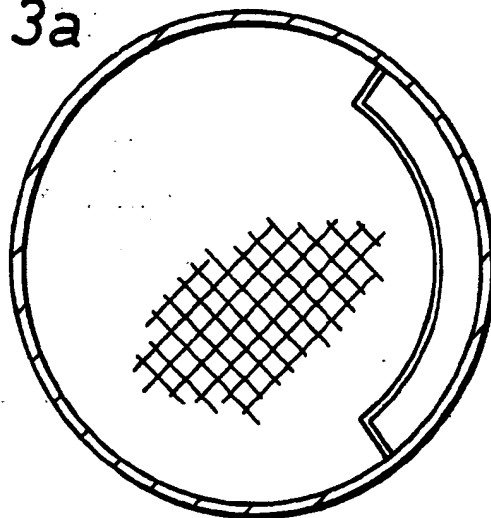
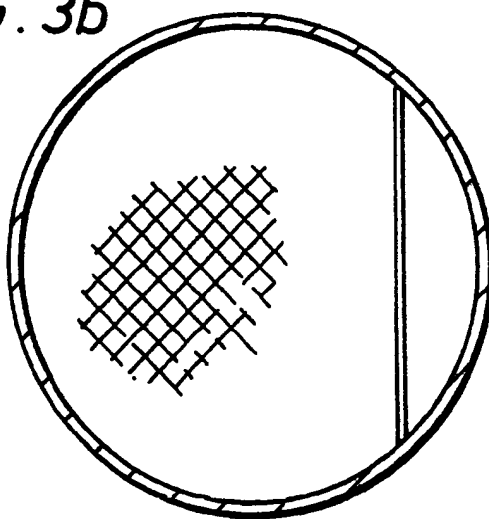


FIG. 3b



QUOTIDIAN SHEET

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/01069

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: C 10 G 11/18														
II. FIELDS SEARCHED <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Minimum Documentation Searched⁷</div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 25%; border-bottom: 1px solid black;">Classification System</th> <th style="border-bottom: 1px solid black;">Classification Symbols</th> </tr> <tr> <td style="padding: 5px; vertical-align: top;">IPC5</td> <td style="padding: 5px; vertical-align: top;">C 10 G</td> </tr> </table> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched⁸</div>			Classification System	Classification Symbols	IPC5	C 10 G								
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III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹ <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%; padding: 5px;">Category *</th> <th style="width: 60%; padding: 5px;">Citation of Document¹¹ with indication, where appropriate, of the relevant passages¹²</th> <th style="width: 30%; padding: 5px;">Relevant to Claim No.¹³</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">EP, A1, 0066725 (ASHLAND OIL, INC.) 15 December 1982, see page 81, line 20 - page 82, line 13; figure 2 ---</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-17</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">EP, A1, 0254333 (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.) 27 January 1988, see figure 3 ---</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-17</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">EP, A1, 0259153 (MOBIL OIL CORPORATION) 9 March 1988, see page 5, line 31 - line 48; figure 1 ---</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-17</td> </tr> </tbody> </table>			Category *	Citation of Document ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	X	EP, A1, 0066725 (ASHLAND OIL, INC.) 15 December 1982, see page 81, line 20 - page 82, line 13; figure 2 ---	1-17	A	EP, A1, 0254333 (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.) 27 January 1988, see figure 3 ---	1-17	A	EP, A1, 0259153 (MOBIL OIL CORPORATION) 9 March 1988, see page 5, line 31 - line 48; figure 1 ---	1-17
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<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>														
IV. CERTIFICATION <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px; vertical-align: top;"> Date of the Actual Completion of the International Search 8th October 1990 </td> <td style="width: 50%; padding: 5px; vertical-align: top;"> Date of Mailing of this International Search Report 20. 11. 90 </td> </tr> <tr> <td style="padding: 5px; vertical-align: top;"> International Searching Authority EUROPEAN PATENT OFFICE </td> <td style="padding: 5px; vertical-align: top;"> Signature of Authorized Officer Natalie Weinberg </td> </tr> </table>			Date of the Actual Completion of the International Search 8th October 1990	Date of Mailing of this International Search Report 20. 11. 90	International Searching Authority EUROPEAN PATENT OFFICE	Signature of Authorized Officer Natalie Weinberg								
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
X	GB, A, 744687 (ESSO RESEARCH AND ENGINEERING COMPANY) 15 February 1956, see page 3, line 16 - line 50; figure 1	1-17
A	GB, A, 2166662 (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ BV) 14 May 1986, see figure 1	1-17

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. PCT/GB 90/01069**

SA 38590

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 28/08/90. The European Patent office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A1- 0066725	15/12/82	US-A- 4407714	04/10/83
EP-A1- 0254333	27/01/88	JP-A- 63004840	09/01/88
		US-A- 4693808	15/09/87
		US-A- 4797262	10/01/89
EP-A1- 0259153	09/03/88	AU-D- 7790187	10/03/88
		JP-A- 63116734	21/05/88
		US-A- 4787967	29/11/88
GB-A- 744687	15/02/56	NONE	
GB-A- 2166662	14/05/86	US-A- 4664889	12/05/87

For more details about this annex : see Official Journal of the European patent office, No. 12/82

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